Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #46741

GIFTS: Development of an Assistive Technology Design Project for Teaching First Year Engineering Students about Creating Value and Human Centered Design

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Introduction

It has been well documented that hands-on, project-based learning can benefit engineering courses [1, 2]. At the University of Denver, the first-year engineering courses have included design projects for several years. These projects have varied from catapults to STEM based preschool toys to dog toys. The hands-on learning opportunities are ideal for first year students because often they are still in introductory math and science courses which can feel like they lack context for the greater engineering world. It is also a great opportunity to introduce students to additional skills such as teamwork, communication, computer aided design, and the overall engineering design process.

Recently our department has looked at adding components of human centered design to coursework. This was selected to both align with a piece of our university's mission which is to be an institution "for the public good," and highlight the impact an engineering design can make for someone in the community. As a part of this undertaking, it was decided that the first-year project would focus on assistive technology and adaptive design for someone connected to the students themselves. This was an opportunity to not only design something useful, but also for students to see how a design can impact someone's life and therefore creating value.

Project Approach

The group project ran over seven weeks of a ten-week quarter. It was scaffolded to move the students through the full engineering design process, allowing for checkpoints on both process and understanding along the way. As the students moved through the project, they were introduced to the steps of the engineering design process through lectures and lab activities. The differentiator between this project and previous iterations was that students were required to go and find someone who could benefit from a design, instead of being given a prescribed set of design goals and requirements.

To begin, students were introduced to the idea of adaptative design and assistive technology in a lecture. The lecture started by looking at what it is like to be left-handed in a right-handed world. Because there are always a few left-handed students in classroom it is a relatable way to describe how things can be designed for the majority of the population which can then make everyday tasks more difficult for those who don't fit into that majority. The lecture then moved into the world of assistive technology and adaptive design describing how it can benefit those who are unable to perform everyday tasks due to physical disability, age, neuro-disability, etc.

The first assignment of the project was an individual assignment (part of their homework grade), and students were asked to interview someone who may benefit from assistive technology or adaptive design. The students were given guidelines and resources about what the interview should contain and were asked to summarize the interview and come up with a problem statement from their interview. Some example problems statements include: "Knitting is difficult for those who struggle with fine motor skills because typical knitting needles are slippery and difficult to grasp." And "Elderly sometimes can have a hard time remembering tasks. This can interfere with personal image and self-sufficiency. A small simple to use memory aid would help with remembering tasks."

In addition to the interview summary, students were also asked to complete an empathy map. The map used is shown in Figure 1 and is based off a similar project published by Kwaczala [3]. The goal of the map is to help students think holistically about what problem they are trying to solve.

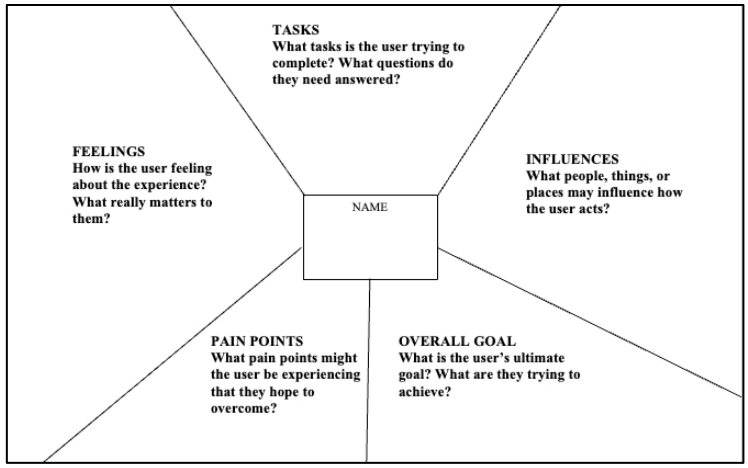

Figure 1: Empathy Map template used by students when completing their interviews.

While completing their interview assignments students were placed into groups of three or four and asked to complete a Team Charter. Once the interviews were complete, the group decided which teammate's problem statement they would like to solve. Students were allowed to adjust their problem statements for them to fit into the scope of the project timeline.

The next project assignment was to come up with goals and requirements for their projects. To make the requirements reasonable and measurable, students were encouraged to research standards and values for the design. For example, if a group was developing a tool to help elderly people pick up things off the ground without bending over, they may research how much weight people of different ages can lift or how much similar tools currently cost. The goals and requirements were then graded by the lab teaching assistants (TAs) and all groups were given feedback to help them focus and improve on their lists.

The fun part of the project began next when students started to brainstorm different ideas to solve their problems. Groups were encouraged to brainstorm broadly and then come up with three or four favorite ideas to select from. Each group was required to use a design matrix based on the goals and requirements they had set up to then select a final design to move forward with. At the end of this process each group presented their work to this point to the course instructor and their lab TA. The presentations were outlined to include specific information including the problem statement, goals and requirements, conceptual designs, design matrix, and a plan for building and testing a design prototype. During the presentation groups received feedback on their work so far and were given suggestions to help them be successful as they completed the final steps.

Once they had received feedback, students began to finalize their designs and started building prototypes for testing. Groups were encouraged to start with low-fidelity prototypes and provided with basic materials such as cardboard, paper, tape, and playdoh. As they moved into more high-fidelity prototypes students were also provided access to the Innovation Labs which includes tools such as 3D printers, laser cutters, sewing machines, and the wood shop.

In parallel to the group project, students were also learning and developing their computer aided design skills through SOLIDWORKS. This portion of the class was described in a previous paper [4] and included a mastery-style method of teaching students how to build, assemble, and make drawings of 3D parts. These skills could then be used by students to build parts for 3D printing or make final engineering drawings to be included in their reports.

The final deliverable was a high-fidelity prototype of their design presented to their lab section and a final design report which combined their work into a single document.

Assessment

To keep the groups on track during the seven weeks, and provide feedback, there were five deliverables assigned, which are described in Table 1.

Table 1: Assessment components of the project.

Deliverable	Description	Percentage of Grade
Team Charters	The goal of this document was to help the team outline goals, scheduling, communication plans, and areas of strength or opportunity.	5%
Requirements Document	This document was used to finalize the problem statement of each group's project, as well as outline the goals and requirements. TAs gave students feedback on these documents via a rubric to help them move forward before starting into their design solutions.	10%
Mini Design Review Presentations	This was an opportunity for each group to present their proposed design idea to the instructor and lab TA. The teams are asked to give a very specific presentation to show their work up to that point. Feedback was given verbally to each group during their presentation and via a rubric.	20%
Final Product Demonstration	The presentations included a project problem statement, an engineering drawing of the final design, and a description of how the design would work along with a demonstration with their prototype. Students in the audience were asked to fill out short peer evaluations to be used for feedback to the groups on their presentations. The instructor and TA completed a rubric for assessment of the presentation.	20%
Final Project Report	At the end of the quarter each team turned in a final document that described their design and process throughout the seven weeks. The report was required to contain the following sections: Introduction and Requirements, Conceptual Design, Detailed Design, Prototyping and Testing, and Future Goals/Conclusions. The report should be developed throughout the quarter as the students work through their design process and take in the feedback given during the different assessment check points.	45%

As often occurs with group projects, not all team members contribute with the same enthusiasm. At the conclusion of the project each team member was asked to fill out a peer evaluation form for each of their teammates and themselves. These forms were then read over by the instructor and TAs and could be used to adjust final project grades.

Discussion

Post course surveys of the student experience showed that overall, the students found the project to be fun and engaging. A summary of the question "What did you like best about the final project?" included answers related to creative freedom, collaboration and teamwork, and the real-world application. For example, one student stated, "I really enjoyed the creative freedom and fact that the instructions were specific and easy to understand, but not too rigid." The variety of projects can be seen in figure 2, which shows examples of the final prototypes students developed and presented.

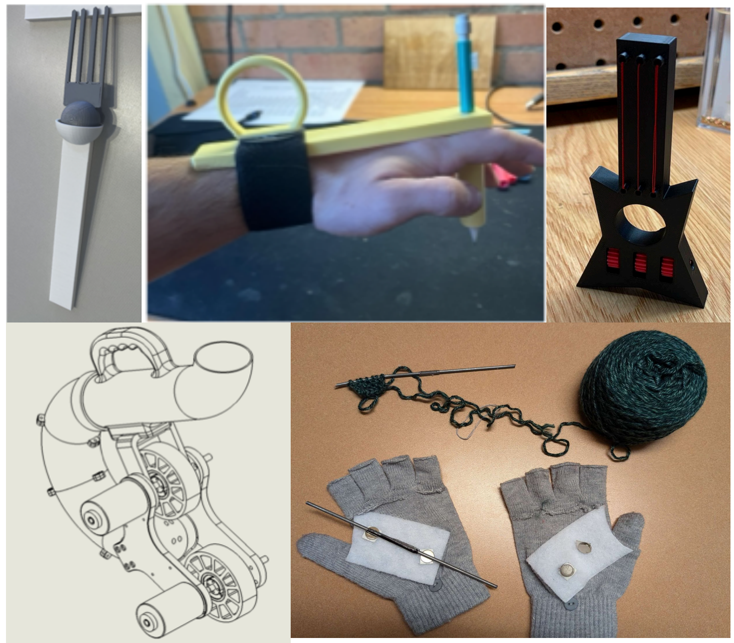

Figure 2: Examples of final designs. Clockwise from the upper left: a fork for people with tremors, a stabilizing writing device for someone with partial paralysis, a novel fidget toy for students with ADHD, a portable tennis ball thrower for a dog owner with a muscle disorder, and magnetic knitting gloves for a person with arthritis.

During a post-project survey many students mentioned that they liked being able to work on a problem that affected someone they knew. For example, when asked their favorite part of the project one student stated, "that it was based on real people who we had to interview." Another mentioned enjoying the ability to select their design goal and said "I liked how we got to pick which problem we wanted to accomplish. With this we were able to make our own design and work through all of the engineering design process on our own. Making it feel like a real situation and what we might have to go through throughout our engineering career." Anecdotally, observations by the GTAs and instructor, who had taught different project iterations, indicated that the students appeared to feel more of a connection to the design problem when it came from someone that they knew instead of being a more prescribed project.

When asked "Given the circumstances, what would you have changed about the final project?" many students indicated a desire to have more time, especially when it came to building their final prototype. There were also some concerns with the teamwork aspect of the project. This came up in a pervious iteration, and so this year there was additional lecture time given to discussing how to best work in teams.

While currently there is not a requirement for our students to present their ideas back to their interviewees, this is being considered for the next iteration as it could help reiterate the value of their creation. Additional iterations of the project will continue, but the overall project structure works well with the limited about of time in a 10-week quarter system and students enjoyed the process.

References

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